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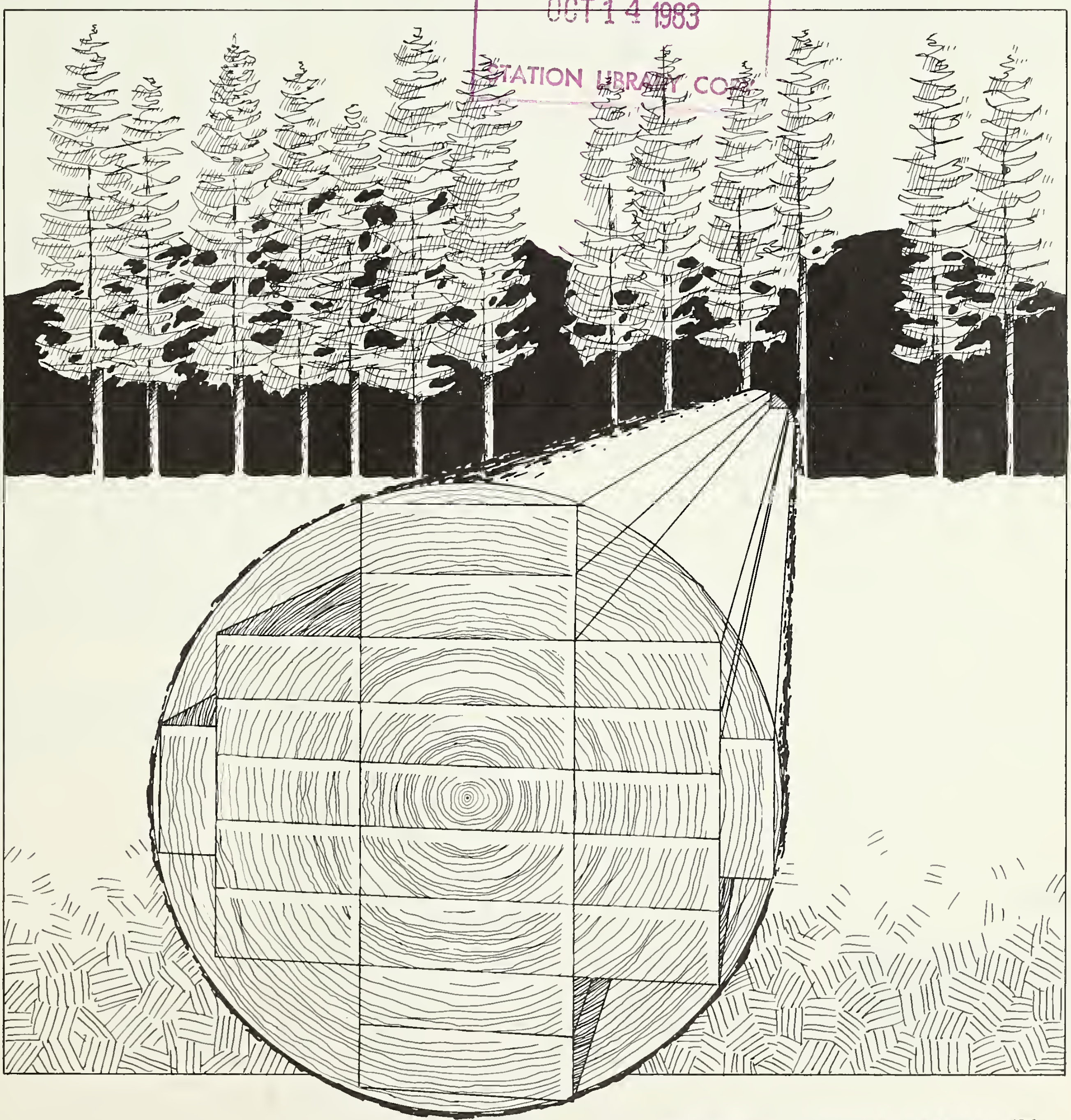
Lumber Recovery From Young-Growth Red and White Fir in Northern California

W.Y. Pong



Author

W.Y. PONG is a research forest products technologist, Pacific Northwest Forest and Range Experiment Station, 809 N.E. Sixth Avenue, Portland, Oregon 97232.

Abstract

Pong, W.Y. Lumber recovery from young-growth red and white fir in northern California. Res. Pap. PNW-300. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1982. 14 p.

Lumber recovery data from 1,106 logs from 341 young-growth white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.) and red fir (*A. magnifica* A. Murr) trees are presented. All logs were processed through a quad-band headsaw. Nominal 2x4's and 2x6's made up over 93 percent of the lumber volume; nearly 70 percent was No. 2 (Standard) and better. Average overrun was 54 percent of net log scale.

Cubic recovery of lumber in rough-green and surfaced-dry conditions averaged, respectively, 53 and 42 percent of gross cubic log volume. The lumber recovery factor averaged 7.5 board feet per cubic foot of gross log volume processed. Recoveries were higher for larger logs.

Standards for minimum thickness and width of rough-green lumber were exceeded in both the 2x4's and 2x6's. Greater tolerances (allowance for surfacing), however, were used in producing 2x4's than 2x6's. As a result, the board feet of lumber recovered from each cubic foot of lumber processed (BFL/CFL ratio) from smaller logs was reduced since these logs were sawn primarily into 2x4's. The average BFL/CFL ratio for all logs was 14.12.

Keywords: Lumber recovery, young growth, red fir, *Abies magnifica*, white fir, *Abies concolor*, California (northern).

Summary

Lumber recovery data from processing through a quad-band sawmill 1,106 logs from 341 young-growth white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.) and red fir (*A. magnifica* A. Murr.) trees selected from the southern Cascade Range of northern California are presented. Over 93 percent of the lumber volume produced was nominal 2x4's and 2x6's. Nearly 70 percent of the lumber graded out as 2-inch No. 2 (Standard) and better. The recovery volume of Economy and No. 3 (Utility) lumber decreased for larger logs. A corresponding increase in upper grades of lumber was recorded from the larger logs.

Overrun for the 1,106 logs was 54 percent; higher overruns were recorded for the smaller diameter logs.

Cubic recovery of surfaced-dry lumber ranged from 34 to 45 percent of gross log volume. Cubic recovery of rough-green lumber ranged from 45 to 57 percent. For all logs, the cubic recovery averaged 42 percent for surfaced lumber and 53 percent for lumber in a green unsurfaced condition.

The lumber recovery factor (LRF) — that is, the board feet of lumber recovered from each gross cubic foot of log processed — varied from 6.2 to 8.1. The average LRF for the 1,106 logs was 7.5 board feet per cubic foot. A higher LRF was recorded for larger logs, the maximum in logs 13 to 14 inches in diameter.

Minimum standards of thickness and width for rough-green lumber were exceeded in both the 2x4's and 2x6's. Sawing tolerances, however, were greater in producing 2x4's than 2x6's. Because of this, the board feet of lumber recovered from each cubic foot of lumber processed (BFL/CFL ratio) was lower for smaller diameter logs since these were sawn primarily into 2x4's. The BFL/CFL ratios ranged from 14.00 to 14.22 board feet per cubic foot. The average for all logs was 14.12.

Contents

Introduction

The western true firs (*Abies* spp.), which have an aggregate volume of 218.8 billion board feet, represent about 14 percent of the commercial softwood sawtimber volume in the West. In California, the true firs represent nearly 29 percent (78.4 billion board feet) of the commercial softwood timber volume of that State. A significant proportion is in young-growth trees less than 140 years old, and more than 22 percent of the sawtimber is in trees less than 22 inches in diameter at breast height (d.b.h.) (USDA Forest Service 1966). In the southern Cascade Range of northern California, young-growth true firs (9.0- to 20.9-inch d.b.h.) represent more than one-third of the 21.2 billion board feet of true firs in that area (Bolsinger 1976).

California red fir (*Abies magnifica* A. Murr.) and white fir (*A. concolor*,(Gord. & Glend.) Lindl. ex Hildebr.), called "white fir" commercially, have become progressively more important as raw material for the wood-using industry. Nearly 29 percent of the 1.8 billion board feet of sawtimber harvested annually from National Forests in California is "white fir." Of this amount, 45 million board feet (about 9 percent of the true fir cut) is derived from young growth. Recent data indicate that an increasing proportion of the annual cut of true firs is young growth. In 1974, about 5 percent of the white fir sawtimber volume removed from National Forests in California was young growth; by 1980, it was almost 11 percent.[1]

Because of the increased use of young-growth true firs, new information on recovery of grade and volume of lumber is needed. Changes in standards of use, manufacturing, and marketing point to the same need. With such information, plant managers could use the true fir resource more efficiently.

A lumber recovery study with the objectives shown below was carried out in 1976 in cooperation with the Pacific Southwest Region National Forest System and the Publishers Paper Company, Burney, California. This report presents results of the first three objectives of that study. Results for objectives 4 and 5 will be reported in another paper.

[1] Personal communication, Frank Oyung, Pacific Southwest Region, U.S. Department of Agriculture, Forest Service, National Forest System, Timber Management.

Objectives

1. To determine lumber and chip yields from logs of young-growth red and white fir.
2. To determine the distribution of lumber grades from young-growth red and white fir.
3. To determine the cubic recovery of young-growth logs of red and white fir.
4. To determine the effect of various characteristics of trees and logs on lumber recovery.
5. To obtain information that will contribute to the development of grading systems for true fir logs and trees.

Procedure

Sample Selection

A total of 341 red fir and white fir trees, considered representative of the range of size and quality of young-growth true fir timber in the southern Cascade Range of northern California, were selected from two areas of the Lassen National Forest (fig. 1). The trees were from stands considered typical young-growth timber stands in that general locale. Individual trees were stratified on the basis of size (diameter at 4½ feet above ground level on the uphill side) and defect (USDA Forest Service 1966). Trees ranged from 7.5- to 24.0-inch d.b.h. An attempt was made to select an equal number of trees in each 1-inch diameter class; this was accomplished except for larger trees (table 1). Because wood of white fir and red fir is similar in structure and properties and because the lumber is graded and sold under the same rules, species information — though recorded — was not used as a basis of stratification during tree selection. Age was checked by increment borings at breast height and ring counts on the stump at the time of felling. All trees selected were under 140 years.

Field Measurements

Before the trees were felled, surface characteristics for the first 32 feet were recorded by relative position (diagramed) (Jackson and others 1963, Pong and Jackson 1971), and other important details of each tree (for example — crook, lean, dominance, broken top, major surface characteristics located above 32 feet) were noted and recorded. Each tree was identified by number, then felled and bucked into lengths according to industry practice. Maximum length of bucked logs was 48 feet plus trim.

While the tree was on the ground and before it was disturbed, characteristics on the visible log surface were again checked for accurate description of type and size. All logs were tagged and numbered by tree and by location in the main stem. Minimum utilization standards applied during the logging operation were 8-foot length, 6-inch scaling diameter,[2] and 25 percent sound. Cull logs (logs less than 25 percent sound) and logs not meeting minimum size requirements were left in the woods. All other logs were removed from the woods and hauled to the sawmill site and dry decked until the sawmill phase of the study.

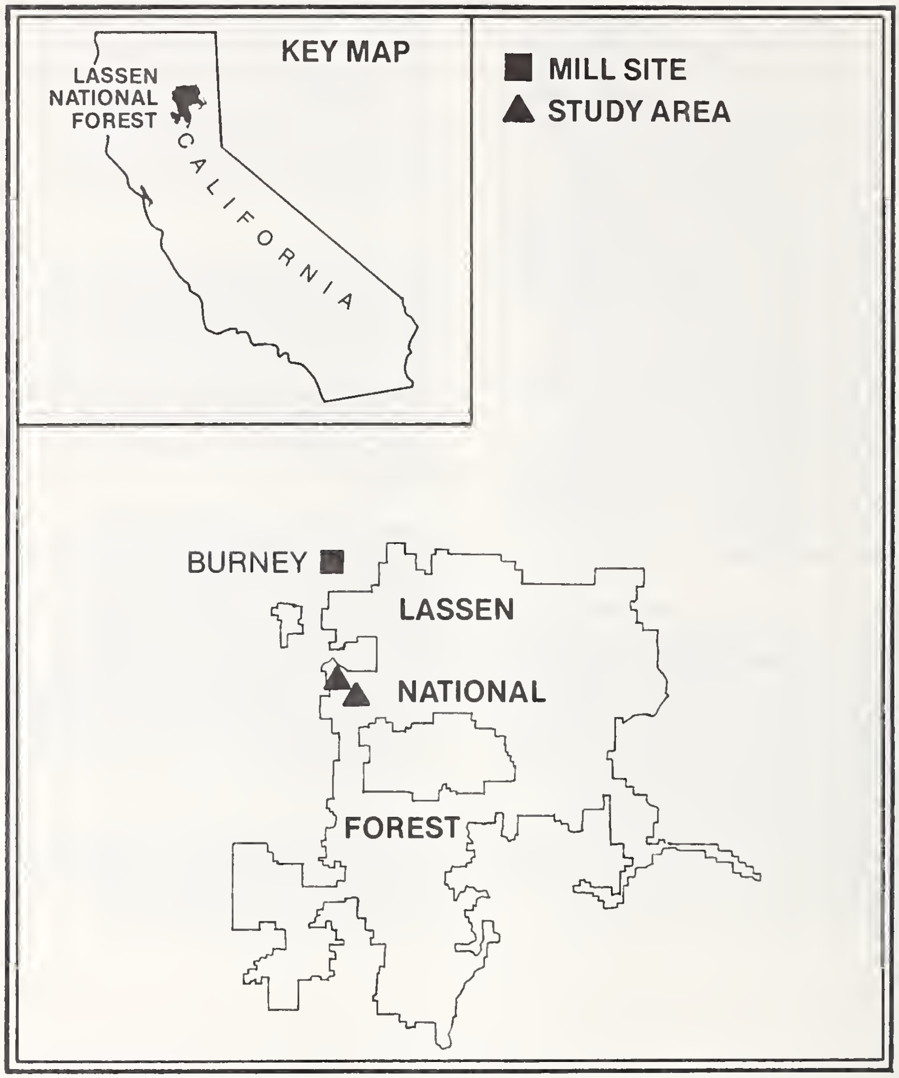


Figure 1. — Approximate location of study areas for young-growth true fir trees and location of mill.

[2] The average diameter, inside bark at the small end of the log, rounded up to the nearest inch.

Table 1 — Distribution of young-growth red and white fir trees by size in study sample, Lassen National Forest

D.b.h. class (range)[1/]	Number of trees
Inches	
7 (6.6 - 7.5)	1
8 (7.6 - 8.5)	23
9 (8.6 - 9.5)	20
10 (9.6 - 10.5)	25
11 (10.6 - 11.5)	20
12 (11.6 - 12.5)	22
13 (12.6 - 13.5)	25
14 (13.6 - 14.5)	22
15 (14.6 - 15.5)	22
16 (15.6 - 16.5)	22
17 (16.6 - 17.5)	25
18 (17.6 - 18.5)	24
19 (18.6 - 19.5)	22
20 (19.6 - 20.5)	23
21 (20.6 - 21.5)	19
22 (21.6 - 22.5)	19
23 (22.6 - 23.5)	4
24 (23.6 - 24.5)	3
Total	341

[1/]Diameter of tree at breast height (4-1/2 feet above ground level on the uphill side).

Table 2 — Distribution of young-growth red and white fir saw logs in study sample, by diameter and length, Lassen National Forest

Diameter	Log length (feet)							Total
	8	10	12	14	16	18	20	
Inches	Number							
6	0	14	44	31	42	17	75	223
7	0	7	11	6	19	3	15	61
8	0	6	25	20	20	4	21	96
9	1	11	17	22	38	6	15	110
10	2	5	19	12	47	7	19	111
11	1	2	16	6	43	4	20	92
12	0	1	13	7	47	8	22	98
13	1	1	9	4	55	2	8	80
14	0	0	11	2	60	0	7	80
15	0	2	2	1	46	0	9	60
16	0	2	3	0	35	0	5	45
17	0	0	5	0	16	0	3	24
18	0	1	2	0	14	0	2	19
19	0	2	0	0	4	0	0	6
20	0	0	0	0	1	0	0	1
Total	5	54	177	111	487	51	221	1,106

Log Grading and Scaling

Before the logs were sawed, each woods-length log was bucked into mill-length logs (20-foot maximum). These were tagged by tree and log location in the tree. Before the logs were debarked, each mill-length log was scaled by USDA Forest Service scalers applying current scaling methods (USDA Forest Service 1969). Grades for these logs were determined from log diagrams using Forest Service grades for white fir (Wise and May 1958) modified for the study (see appendix). There were 1,106 mill-length logs, ranging from 6 to 20 inches in diameter and from 8 to 20 feet in length (table 2); all were Grade III, High Common logs.

Processing

Each log was sawed to meet scheduled mill production needs through the manufacture of 2x4 and 2x6 lumber items. Sawing practices conformed to general industry practice in California of maximizing lumber production and grade and were geared to produce Board and Dimension grades of lumber. All lumber was sawed to meet West Coast Lumber Inspection Bureau (WCLIB) specifications of grades and sizes (West Coast Lumber Inspection Bureau 1970).

Equipment in the sawmill included a debarker, computer controlled quad-band headsaw, single band resaw, two double arbor edgers, a gang trim saw, an automatic pocket drop sorter, and a lumber stacking and stickering machine.

When they were sawed, logs were assigned a sequential sawing number cross-referenced to the tree log number. Lumber from each log was tracked through the processing phase by a coded combination of colors and the subsequent marking of each piece of lumber with the sequential sawing number of each log. All rough-green lumber was sorted by width, thickness, and length. Dimension lumber was dried in modern, single track, internal fan, cross-circulation kilns; Board grades of lumber were air dried.

Dimension grades of lumber were surfaced four sides and graded. Board grades of lumber were not surfaced but were sent through the planer and graded in a rough-dry condition with an anticipated surfaced-dry grade (West Coast Lumber Inspection Bureau 1970). A hand and voice tally (on magnetic tape) and a photographic tally were made of each piece of lumber on the infeed of the planer; hand and photographic tallies were made on the outfeed. Grading of the lumber was under the general supervision of a WCLIB grading inspector, and all items were graded according to the national grading rules for dimension lumber and appropriate regional rules as published by the WCLIB (West Coast Lumber Inspection Bureau 1970).

Tallied data for each piece of lumber included length, width, thickness, grade, and sequential sawing number of the log.

Data Compilation

The hand-tallied, surfaced-dry lumber data were edited and corrected using the photographic tally made on the planer outfeed. The hand tally of sequential sawing numbers made on the planer infeed was edited and corrected using both the voice and photographic tally. The corrected hand tallies were then matched and merged.

All data were transferred to punchcards and compiled using computer programs written specifically for handling recovery data (Henley and Hoopes 1967).

Compiled board-foot volumes of lumber tally presented in this paper are based on nominal dimensions of the lumber produced; cubic volumes were computed using rough-green and surfaced-dry lumber sizes.

Gross cubic log volumes were computed by the formula (Grosenbaugh 1966):

$$V = 0.005454 \frac{(D_s^2 + D_s D_e + D_e^2)}{3} L \quad ;$$

where:

V = gross cubic-foot log volume;

D_s = average small end scaling diameter inside bark in inches;

D_e = average large end scaling diameter inside bark in inches; and

L = log scaling length in feet.

Losses in cubic volume of lumber resulting from drying and surfacing were determined by subtracting computed surfaced-dry lumber volumes from corresponding green lumber volumes. Volume of wood converted to sawdust was calculated by applying an average saw kerf of 0.135 inch to one-half the rough-green surface area of each piece of lumber produced. Green lumber dimensions used in this computation and in computing green cubic lumber volume were based on sample measurements of rough-green lumber.

Volumes of chippable residue were determined by subtracting from the gross cubic log volumes the cubic volumes of rough-green lumber (that is, the volume of surfaced-dry lumber plus the losses of volume from surfacing and drying) and the calculated sawdust volumes.

Data Analysis

The compiled data were analyzed by analysis of variance using the programs BIMED (Dixon 1967) and SPSS (Nie and others 1975) for selecting the curve forms for regressing the recovery data to log diameter. For regression purposes, the sample of logs was assumed to be an independent random sample from young-growth red and white fir. Several curve forms using log diameter and various transformations of log diameter as independent variables were tried. Dependent variables regressed were: (1) overrun (percent of lumber tally volume greater than net log scale), (2) surfaced-dry cubic lumber recovery ratio (percent of gross cubic log volume recovered as surfaced-dry cubic volume of lumber), and (3) lumber recovery factor (LRF) (board feet of lumber recovered from each gross cubic foot of log processed) (Fahey and Woodfin 1976).

The final curve forms selected for regressing recovery data to log diameter were based primarily on the regression models having the highest coefficient of determination and lowest standard deviation from regression. In some cases, the magnitude of these measures was comparable for the different models that were tried; the curve form selected, in these instances, was based more on the general shape of the curve through the range of data regressed than on the statistics of the model. Curve forms that did not conform to the general logical relationship between the variables as defined by current knowledge were rejected.

Results

Table 3 — Log scale, lumber tally, and cubic volumes by scaling diameter of young-growth red and white fir sawn-length logs in study sample, Lassen National Forest

Log scaling diameter	Number of logs	Log scale[1/]: Gross	Log scale[1/]: Net	Defect	Lumber tally: Volume[2/]	Lumber tally: Recovery ratio[3/]	Cubic tally: Log[4/]	Cubic tally: Lumber[5/]	Cubic tally: Drying and surfacing losses[6/]	Lumber recovery and loss ratio[7/]: Surfaced-dry	Lumber recovery and loss ratio[7/]: Rough-green	Lumber recovery and loss ratio[7/]: Loss[8/]	Sawdust	Chippable residue
Inches		- - Board feet - -		Percent	Board feet	Percent	- - - - - Cubic feet	- - - - -		- - - - Percent	- - - -		- - Cubic feet	- -
6	223	3,570	3,560	0[9/]	7,333	206.0	1,154.67	402.04	121.56	34.8	45.3	10.5	61.89	569.18
7	61	1,510	1,480	2.0	2,311	156.1	369.33	126.55	38.01	34.3	44.6	10.3	19.39	185.38
8	96	2,370	2,340	1.3	4,351	185.9	664.79	240.32	68.49	36.1	46.5	10.3	35.51	320.47
9	110	3,870	3,820	1.3	6,528	170.9	943.30	363.35	99.39	38.5	49.1	10.5	52.14	428.42
10	111	5,840	5,760	1.4	8,859	153.8	1,189.54	496.99	131.84	41.8	52.9	11.1	69.93	490.78
11	92	5,980	5,800	3.0	9,575	165.1	1,207.78	541.49	136.42	44.8	56.1	11.3	73.56	456.31
12	98	8,000	7,900	1.3	12,374	156.6	1,563.69	699.48	176.00	44.7	56.0	11.3	94.89	593.32
13	80	7,740	7,560	2.3	11,031	145.9	1,409.44	622.41	159.12	44.2	55.4	11.3	85.38	542.53
14	80	8,770	8,510	3.0	13,079	153.7	1,681.79	734.30	191.44	43.7	55.0	11.4	101.94	654.11
15	60	8,580	8,370	2.4	11,903	142.2	1,486.31	661.92	179.61	44.5	56.6	12.1	94.30	550.48
16	45	7,140	6,880	3.6	9,677	140.7	1,255.85	538.06	144.55	42.8	54.4	11.5	76.11	497.13
17	24	4,270	4,050	5.2	5,834	144.0	780.83	325.81	86.74	41.7	52.8	11.1	45.83	322.45
18	19	3,930	3,750	4.6	4,834	128.9	652.02	269.74	72.16	41.4	52.4	11.1	38.11	272.01
19	6	1,260	1,230	2.4	1,676	136.3	206.53	93.72	24.64	45.4	57.3	11.9	13.08	75.09
20	1	280	280	0	303	108.2	42.35	16.81	4.49	39.7	50.3	10.6	2.37	18.68
Total or average[10/]	1,106	73,110	71,290	2.5	109,668	153.8	14,608.22	6,132.99	1,634.46	42.0	53.2	11.2	864.43	5,976.34

1/Scribner scale.
2/Based on nominal lumber dimensions.
3/Percent of net log scale.
4/Gross volume.
5/Based on actual size of surfaced-dry lumber.
6/Calculated loss of volume from shrinkage and planer shavings.
7/Percent of gross cubic log volume.
8/Based on actual loss of volume.
9/Less than 0.5 percent.
10/Weighted by volume.

Log Scale, Lumber Tally, and Cubic Volumes

Table 3 summarizes the log scale, surfaced-dry lumber tally, and cubic volume of the logs. Defect ranged from 0 to 5.2 percent, the more defective logs occurring in logs with larger diameters. The defect for all logs averaged 2.5 percent ($CI_{95} = \pm 0.53$)[3]

Higher values of overrun — that is, percent of board-foot lumber volume greater than Scribner net log scale (equivalent to lumber recovery ratio minus 100) — were recorded for logs with smaller diameters. The regression curve of overrun to log scaling diameter (significantly correlated at the 1-percent level) and the scattergram are presented in figure 2. Board-foot lumber recovery ratio (overrun plus 100) ranged from 108.2 to 206.0 percent of Scribner net log scale and averaged 153.8 percent ($CI_{95} = \pm 2.07$) (table 3).

[3] Confidence interval at the 95-percent level.

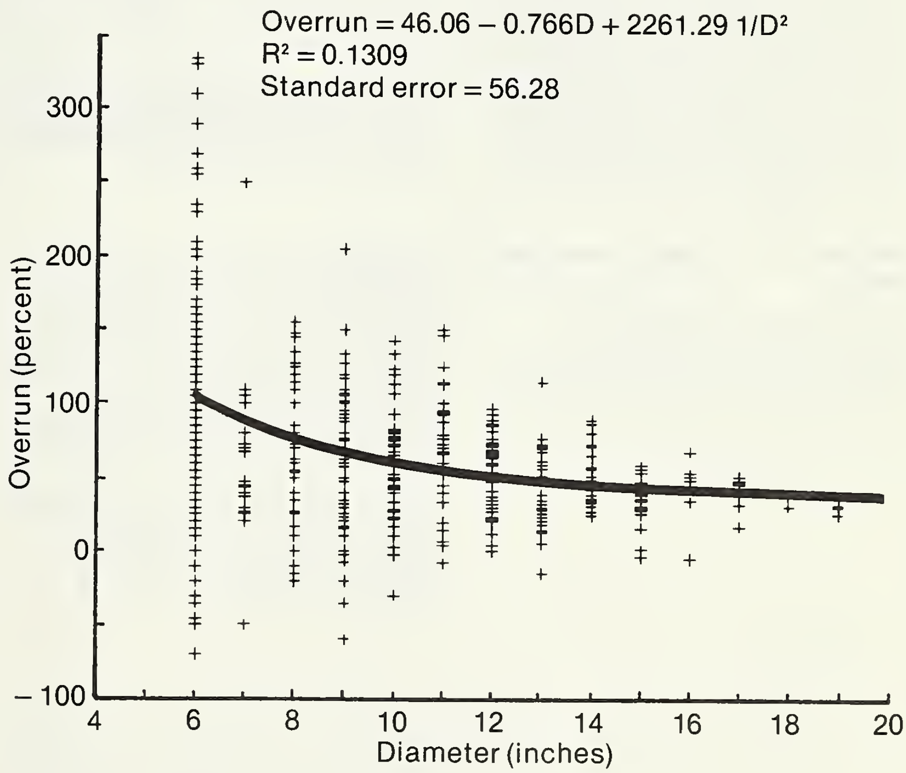


Figure 2. — Overrun (percent of board-foot lumber volume greater than net log scale) for logs from young-growth red and white fir, by scaling diameter.

Cubic volumes of surfaced-dry lumber recovered from the logs varied from 34.3 to 45.4 percent of gross cubic log volumes. Comparable cubic volume recovered for rough-green lumber (that is, the volume of surfaced lumber plus drying and surfacing losses), varied from 44.6 to 57.3 percent. The cubic-foot recovery ratio for all logs combined for surfaced-dry lumber averaged 42.0 percent ($CI_{95} = \pm 0.67$) and for rough-green lumber 53.2 percent ($CI_{95} = \pm 0.83$) (table 3). A curve regressing the cubic recovery ratio of surfaced-dry lumber to log scaling diameter (significantly correlated at the 1-percent level) and the scattergram are presented in figure 3. Cubic recovery of surfaced material was greater for larger logs, indicating a greater proportion of the cubic volume of larger logs is converted to products and less is lost to slabs to produce lumber of minimum width. There is, however, concom itant increase in the proportion of the volume lost to defect and to drying and surfacing (table 3), both of which reduce the recoverable cubic volume of dry lumber that can be sawn from larger logs. Losses caused by surfacing and drying varied from 10.3 to 12.1 percent of gross cubic log volume and averaged 11.2 percent for all logs ($CI_{95} = \pm 0.17$). Greater losses were recorded for logs larger than 10 inches in diameter.

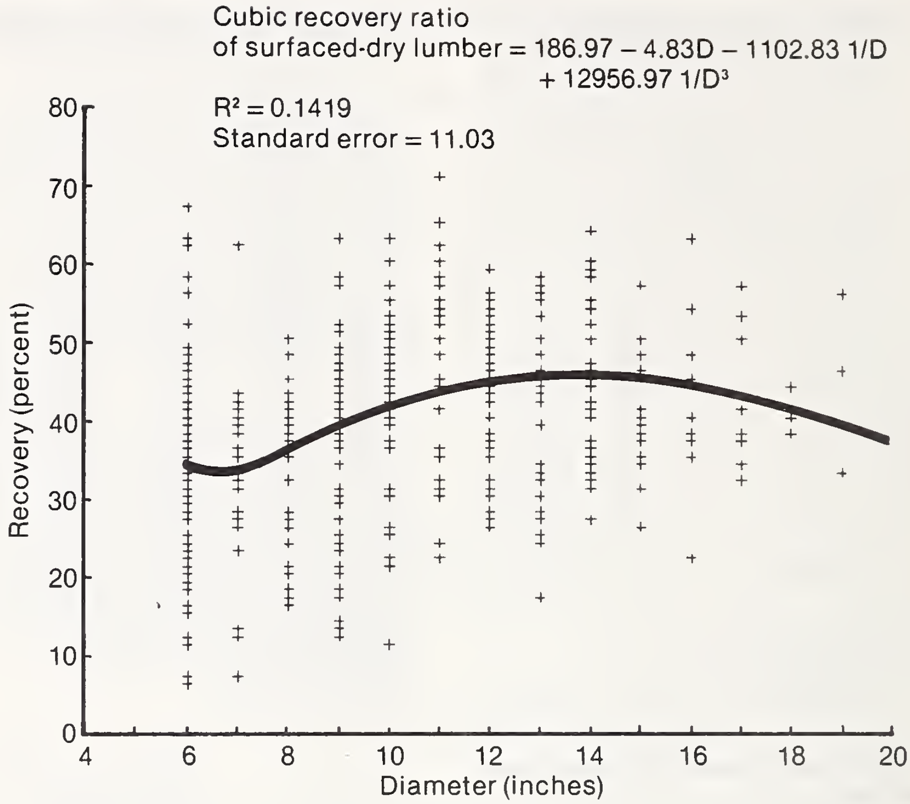


Figure 3. — Cubic volume of surfaced-dry lumber recovered as percent of gross cubic volume of logs from young-growth red and white fir, by scaling diameter.

Distribution of Lumber Grades and Sizes

The percentage yields of various grades and sizes of surfaced-dry lumber produced from the study logs are presented in table 4.

Except for a small volume of 1-inch boards (3.52 percent), all the lumber produced was in 2-inch Dimension grades; nominal 2x4's (43.31 percent) and 2x6's (49.96 percent) were the bulk (93.27 percent) of the lumber tally volume (table 4). A small percentage (3.21) of 2x3's made up the remainder.

Nearly 70 percent of the lumber graded out as 2-inch No. 2 (Standard) and better lumber. Over 72 percent of the lumber items graded out as No. 2 (Standard) and better.

Lumber Grade Yield by Log Diameter

The percentage distributions of lumber grade volume by log scaling diameter are presented in table 5 and figures 4 and 5. Both Economy and No. 3 (Utility) recorded a decrease in recovery volume as log size increased. Percent yield for the remaining grades of lumber increased as log diameter increased (table 5 and fig. 4). The combined effect of these increases is reflected in a greater percentage of No. 2 (Standard) and better lumber recovered from larger logs (fig. 5).

Table 4 — Lumber tally of Board and Dimension lumber, by thickness, width, and lumber grade, for sawn-length logs of young-growth red and white fir in study sample, Lassen National Forest

Thickness	Width	Lumber tally volume	Lumber grade: Select structural	No. 1[1/]	No. 2[2/]	No. 3[3/]	Economy	Total
- - - - Inches - - - -		Board feet	- - - - - - - - - - -Percent of lumber tally- - - - - - - - - - -					
1 (4/4)	4	2,015	--	0.76	0.57	0.29	0.22	1.84
	6	1,842	--	.49	.62	.30	.27	1.68
Total Board items		3,857	--	1.25	1.19	.59	.49	3.52
2 (8/4)	3	3,527	0	.63	1.25	.98	.35	3.21
	4	47,496	5.58	13.39	13.28	7.81	3.25	43.31
	6	54,788	6.65	12.17	17.04	10.77	3.33	49.96
Total Dimension items		105,811	12.23	26.19	31.57	19.56	6.93	96.48
			- - - - - - - - - - - - - - - - Percent- - - - - - - - - - - - - - -					
Total of grades (percent)		--	12.23	27.44	32.76	20.16	7.41	100.00
			- - - - - - - - - - - - - - - -Board Feet- - - - - - - - - - - - - -					
Total volume		109,668	13,408	30,095	35,933	22,108	8,124	--

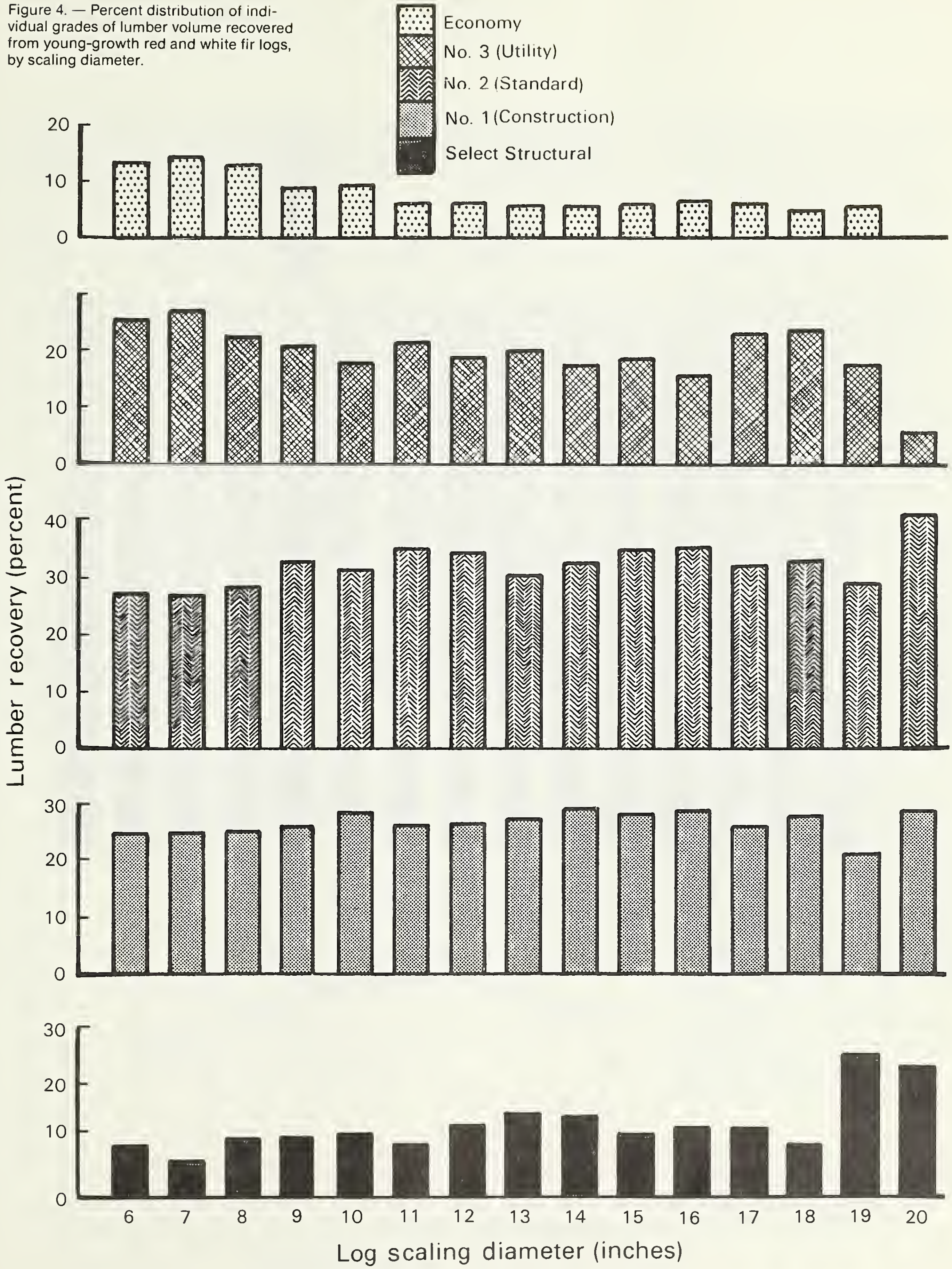
1/Includes Construction grade 2x3's, 2x4's, and 1-inch boards.
2/Includes Standard grade 2x3's, 2x4's, and 1-inch boards.
3/Includes Utility grade 2x3's, 2x4's, and 1-inch boards.

Table 5 — Lumber grade yields by log scaling diameter of young-growth red and white fir sawn-length logs in study sample, Lassen National Forest

Log scaling diameter	Number of logs	Lumber tally volume	Lumber Grade: Select structural	No. 1[1]	No. 2[2]	No. 3[3]	Economy
Inches		Board feet	Percent of lumber tally volume[4]				
6	223	7,333	8.89	24.90	27.12	25.81	13.27
7	61	2,311	6.79	25.01	27.04	27.09	14.06
8	96	4,351	10.48	25.33	28.34	22.55	13.31
9	110	6,528	10.59	26.23	32.94	21.26	8.99
10	111	8,859	11.81	29.00	31.75	18.12	9.32
11	92	9,575	9.61	26.59	35.61	21.86	6.33
12	98	12,374	13.27	26.82	34.74	19.12	6.04
13	80	11,031	15.13	27.91	30.79	20.20	5.97
14	80	13,079	14.37	29.48	32.59	17.68	5.88
15	60	11,903	11.57	28.17	35.31	19.01	5.94
16	45	9,677	12.70	29.10	35.59	15.88	6.73
17	24	5,834	12.34	26.12	32.26	22.99	6.29
18	19	4,834	9.64	28.24	33.47	23.93	4.72
19	6	1,676	25.84	21.60	28.82	17.84	5.91
20	1	303	23.43	29.04	41.58	5.94	0
Total or average	1,106	109,668	12.23	27.44	32.76	20.16	7.41

[1]Includes Construction grade 2x3's, 2x4's, and 1-inch boards.
[2]Includes Standard grade 2x3's, 2x4's, and 1-inch boards.
[3]Includes Utility grade 2x3's, 2x4's, and 1-inch boards.
[4]Percentages for all grades combined may not total to 100 because of rounding.

Figure 4. — Percent distribution of individual grades of lumber volume recovered from young-growth red and white fir logs, by scaling diameter.



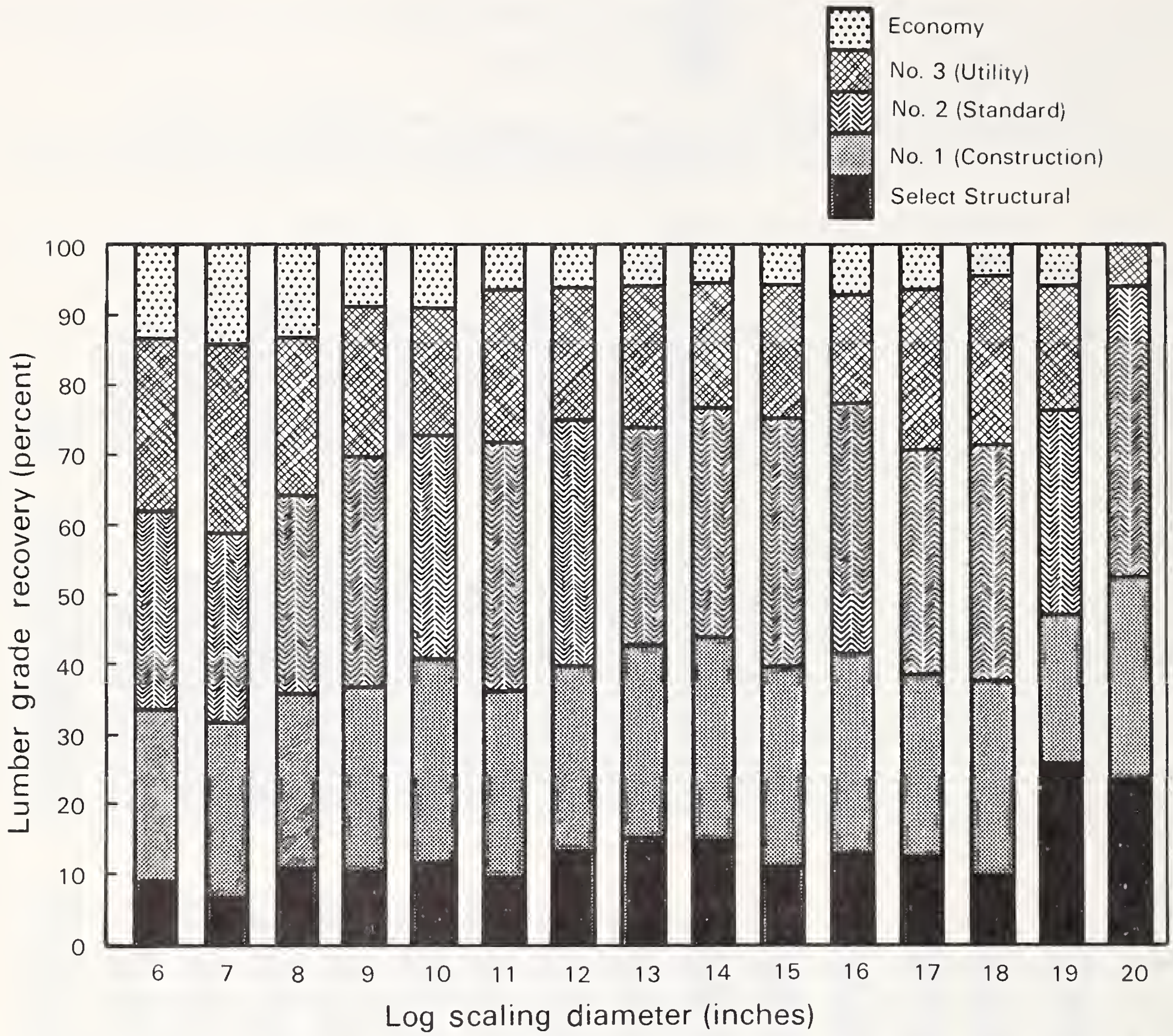


Figure 5. — Percent of lumber grade volumes recovered from young-growth red and white fir logs, by scaling diameter.

Lumber Recovery Factor

Table 6 — Lumber recovery factor and the nominal board-foot volume of lumber tallied per cubic-foot volume of green lumber, by log scaling diameter of young-growth red and white fir sawn-length logs in study sample, Lassen National Forest

Log scaling diameter	Number of logs	Lumber tally volume[1]/	Log volume[2]/	Lumber volume[3]/	Lumber recovery factor[4]/	BFL/CFL[5]/
Inches		Board feet	- - -Cubic	feet- - -	Board feet per	cubic foot
6	223	7,333	1,154.67	523.60	6.3	14.00
7	61	2,311	369.33	164.56	6.3	14.04
8	96	4,351	664.79	308.81	6.5	14.09
9	110	6,528	943.30	462.74	6.9	14.11
10	111	8,859	1,189.54	628.83	7.4	14.09
11	92	9,575	1,207.78	677.91	7.9	14.12
12	98	12,374	1,563.69	875.48	7.9	14.13
13	80	11,031	1,409.44	781.53	7.8	14.11
14	80	13,079	1,681.79	925.74	7.8	14.13
15	60	11,903	1,486.31	841.53	8.0	14.14
16	45	9,677	1,255.85	682.61	7.7	14.18
17	24	5,834	780.83	412.55	7.5	14.14
18	19	4,834	652.02	341.90	7.4	14.14
19	6	1,676	206.53	118.36	8.1	14.16
20	1	303	42.35	21.30	7.5	14.22
Total or average[6]/	1,106	109,668	14,608.22	7,767.45	7.5	14.12

[1]/Nominal lumber dimensions.
[2]/Gross volume.
[3]/Actual green size.
[4]/A ratio of the nominal board-foot volume of lumber recovered from each gross cubic foot of log processed.
[5]/Nominal board-foot volume of lumber (BFL) tallied per measured cubic foot volume of green lumber (CFL).
[6]/Weighted by volume.

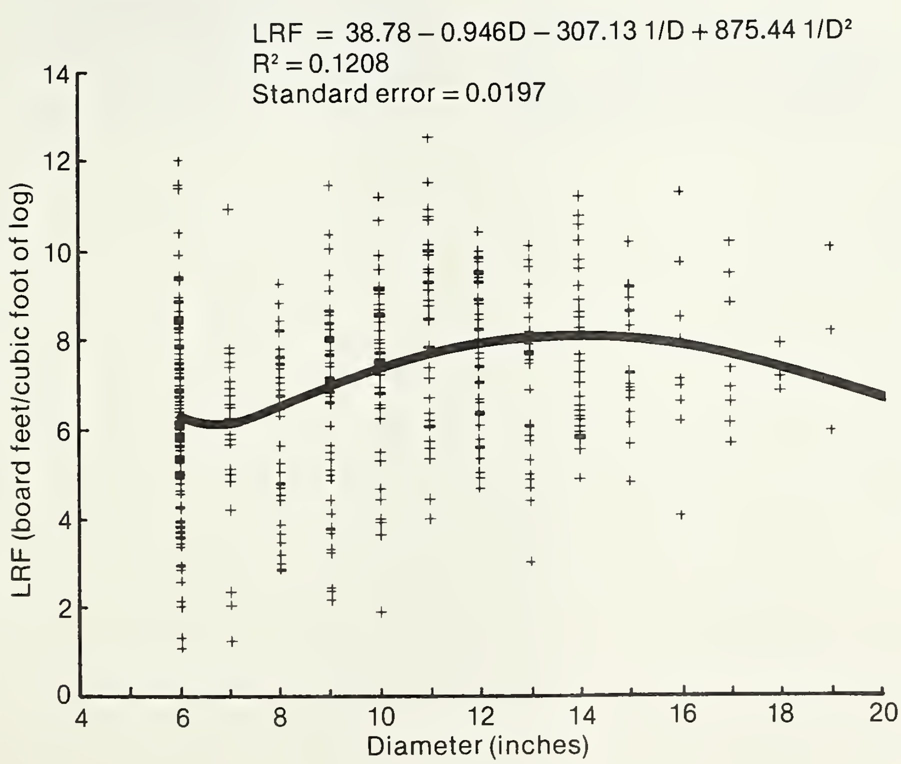


Figure 6. — Lumber recovery factor (LRF) — nominal board-foot volume of lumber recovered from each gross cubic foot of log processed — for young-growth red and white fir logs, by log scaling diameter.

The board feet of lumber recovered from each gross cubic foot of log processed — that is, the lumber recovery factor (Fahey and Woodfin 1976) — varied from 6.3 to 8.1 board feet per cubic foot (table 6). The LRF for all logs combined averaged 7.5 ($CI_{95} = \pm 0.12$). A curve regressing lumber recovery factor to log scaling diameter (significantly correlated at the 1-percent level) and the scattergram of LRF are presented in figure 6. LRF increased as log size increased, up to diameters of 13 to 14 inches and then decreased in the larger logs. As expected, the cubic and LRF curves are similar since the cubic recovery volumes are a direct conversion of the board-foot volumes using the actual surfaced dimensions of the boards. Since over 93 percent of the volume produced was 2x4's and 2x6's (table 4), such a conversion was nearly uniform over the diameter range of logs included in the study.

Board Feet Per Cubic Foot of Lumber

The board feet of lumber recovered from each cubic foot of rough-green lumber processed (BFL/CFL) (Fahey and Woodfin 1976) varied from 14.00 to 14.22 board feet per cubic foot and averaged 14.12 ($CI_{95} = \pm 0.0077$) (table 6). Higher BFL/CFL ratios were recorded for the larger logs suggesting that lumber sawn from these logs was closer to the green targeted sizes (minimum standards of thickness and width of rough-green lumber) than that from the smaller logs. Measurements of green lumber showed that the specification standards for minimum thickness and width of rough unseasoned lumber (West Coast Lumber Inspection Bureau 1970) were exceeded for 2x4's and 2x6's (table 7). Furthermore, oversizing of the green lumber dimensions was greater in the 2x4's than the 2x6's. This was particularly evident in the width of the rough-green 2x4's which exceeded the minimum targeted

Table 7 — Average thickness and width of 2x4 and 2x6 lumber sawn from young-growth red and white fir logs in study sample, Lassen National Forest

Sawing profile	Lumber item	Thickness			Width		
		Actual	Target[1/]	Difference	Actual	Target[1/]	Difference
		- -1/32-inch- -		Percent	- -1/16-inch- -		Percent
2x4	2x4	54.58	54.00	1.07	63.69	59.00	7.95
	2x6	54.43	54.00	.80	94.98	92.00	3.24
2x6	2x4	54.90	54.00	1.67	63.07	59.00	6.90
	2x6	54.65	54.00	1.20	94.63	92.00	2.86

[1/]Target sizes are based on the 1970 edition of West Coast Lumber Inspection Bureau's "Standard Grading Rules for West Coast Lumber," No. 16, p. 157, sec. 250 and 250-a, under "Size Standards Minimum Rough Sizes, Thicknesses and Widths, Dry or Unseasoned."

size by almost 7 to 8 percent (8/32 to 9/32 inch), whereas the 2x6's were oversize in width by only about 3 percent (5/32 to 6/32 inch).

Primary breakdown of logs in the sawmill was through a quad-band headsaw which was controlled by computer to cut either a 2x4 or 2x6 profile. There was no provision for recycling cants through the headsaw. Because of this, the size of cants produced at the headsaw was mainly controlled by log size; smaller logs produced 4-inch cants and larger logs, 6-inch cants. Any difference in sawing tolerances of the quad-band headsaw that may be specific to a given cant size will, therefore, be reflected in the observed changes in the BFL/CFL ratios with log size. Results suggest that oversizing of the 2x4's had a greater impact in reducing the BFL/CFL ratios of the smaller logs than the larger logs, since the smaller logs were cut primarily into 2x4's regardless of profile.

Conclusions

This report presents lumber recovery data from the processing of 1,106 logs from 341 young-growth white and red fir trees from the southern Cascade Range of northern California.

Diameters of study logs ranged from 6 to 20 inches inside bark at the small end and were all Grade III, High Common logs. Defect ranged from 0 to 5 percent; the more defective logs occurred in the larger diameters.

Overrun for all logs averaged 54 percent. As expected, the smaller logs had greater overrun. Board-foot lumber recovery was 108 to 206 percent of Scribner net log scale.

Cubic recovery of surfaced-dry lumber varied from 34 to 45 percent of gross cubic log volume. Comparable values for green, unsurfaced lumber were 45 to 57 percent. Cubic recovery from all logs averaged 42 percent for surfaced lumber and 53 percent for green, unsurfaced lumber. Greater cubic recovery was recorded for larger logs.

Though cubic recovery was greater for larger logs, the proportion of the volume lost during drying and surfacing the material from these logs was greater. Losses ranged as low as 10.3 percent of gross cubic volume in smaller logs to a high of 12.1 percent in larger logs.

Over 93 percent of the lumber produced was Dimension grade 2x4's and 2x6's. A small percentage (3.5) was 1-inch boards, and the remainder (3.2 percent) was 2x3's. Nearly 70 percent of the lumber graded out as 2-inch No. 2 (Standard) and better lumber. The volumes of both Economy and No. 3 (Utility) recovered dropped as log size increased. This resulted in increased yield of No. 2 (Standard) and better lumber.

The lumber recovery factor varied from 6.3 to 8.1. The average for all logs was 7.5 board feet per cubic foot. A greater LRF was recorded for larger logs than for smaller logs.

Minimum standards for thickness and width of rough unseasoned lumber were exceeded in both the 2x4's and 2x6's. Sawing tolerances used in producing 2x4's, however, were greater than those used to produce 2x6's. Because of this, oversize 2x4's had a greater impact in reducing the board feet of lumber recovered from each cubic foot of rough-green lumber processed (BFL/CFL ratio) for smaller logs than for larger logs since the smaller logs were cut primarily into 2x4's.

Metric Equivalents

1 inch = 2.54 centimeters
1 foot = 0.304 8 meter
1 cubic foot = 0.028 32 cubic meter

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Appendix

White Fir Log Grades[4]

Grade 1, select logs. — Logs are at least 90 percent surface clear, straight and generally smooth. Spiral grain is not to exceed 1 in 5. A straight grained frost crack is permitted in an otherwise high-grade log. This grade allows any *one* of the following:

1. One branch or branch stub in the central zone (the part of the log more than 1 foot from either end) larger than 3 inches in diameter.

2. Two scattered branches or branch stubs in the central zone less than 3 inches in diameter or four scattered pin (½-inch diameter) branches or branch stubs.

3. Any number of branches or branch stubs of any size within 1 foot of one end.

4. Concentrated grouping of branches or branch stubs of any size or other defects affecting not over one-fourth of the circumference for a length of 6 feet from one end.

5. A line of branches or branch stubs less than 3 inches in diameter for the full length of the log (one larger branch or branch stub permitted) that affects a strip of the circumference not wider than three-tenths of the log diameter (inside bark) at the small end.

Grade II, shop logs. — Logs are 50 percent surface clear in length or circumference. Also includes shop logs on which the branches or branch stubs, or other defects, are so distributed as to produce factory cuttings. On such logs, 50 percent or more of the surface should be in clear areas, at least 8 feet in length and 6 inches or more in width between branches, branch stubs, and other defects.

Grade III, high common logs. — Logs are less than 50 percent surface clear and can have any combination of branches and branch stubs or other defects that are not permitted on the higher grades. Any number of branches and branch stubs not over 3 inches in diameter (inside bark).

Grade IV, low common logs. — This grade allows logs not qualifying for grades I, II, or III.

General Specifications and Definitions

These grades are for application to merchantable sound sapwood 16-foot logs as cruised in standing trees.

Minimum merchantability requirements are 8-foot length, 6-inch top d.i.b., and net scale at least 25 percent of gross scale.[5]

Branches and branch stubs include live and dead material. So-called knot indicators or overgrown limbs are not considered for grading logs.

Defects include:

1. Scars or seams resulting from lightning, fire, or mechanical damage, providing they are old enough that the underlying wood is stained, pitchy, checked, or otherwise degraded.

2. Large burls that cover more than one-quarter of the log circumference.

3. Unsound burls that are partially dead or show heavy flow of pitch or exudate.

4. Cracks resulting from frost, wind, or other natural causes.

5. Cankers resulting from mistletoe, rusts, or other causes.

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[4] Wise and May (1958); modified as shown in footnote 5.

[5] Changed from 10-foot length, 10-inch top d.i.b., and net scale at least 33-1/3 percent of gross scale.

Pong, W.Y. Lumber recovery from young-growth red and white fir in northern California. Res. Pap. PNW-300. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station; 1982. 14 p.

Lumber recovery data from 1,106 logs from 341 young-growth white fir (*Abies concolor* (Gord. & Glend.) Lindl. ex Hildebr.) and red fir (*A. magnifica* A. Murr) trees are presented. All logs were processed through a quad-band headsaw. Nominal 2x4's and 2x6's made up over 93 percent of the lumber volume; nearly 70 percent was No. 2 (Standard) and better. Average overrun was 54 percent of net log scale.

Cubic recovery of lumber in rough-green and surfaced-dry conditions averaged, respectively, 53 and 42 percent of gross cubic log volume. The lumber recovery factor averaged 7.5 board feet per cubic foot of gross log volume processed. Recoveries were higher for larger logs.

Standards for minimum thickness and width of rough-green lumber were exceeded in both the 2x4's and 2x6's. Greater tolerances (allowance for surfacing), however, were used in producing 2x4's than 2x6's. As a result, the board feet of lumber recovered from each cubic foot of lumber processed (BFL/CFL ratio) from smaller logs was reduced since these logs were sawn primarily into 2x4's. The average BFL/CFL ratio for all logs was 14.12.

Keywords: Lumber recovery, young growth, red fir, *Abies magnifica*, white fir, *Abies concolor*, California (northern).

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Pacific Northwest Forest and Range
Experiment Station
809 NE Sixth Avenue
Portland, Oregon 97232

GPO 996-127